EVALUATION OF UNDER-EXPLOITED SOURCES OF NON STARCH POLYSACCHARIDES FROM WEST AFRICA

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ABSTRACT:

A study of under-exploited sources of non-starch polysaccharides from West African food was carried out on four commonly used traditional plant food thickeners namely, Grewia spp., Triumfetta spp., Beilschmiedia spp. and Irvingia gabonensis, bought from the markets of Maroua, Garoua and Ngaoundere in Cameroon. The extraction and isolation of water-soluble non-starch polysaccharides (s-NSP) were performed using standard analysis test to determine the intrinsic viscosity, the purity of the extracted s-NSP and original flours, as well as the concentration of polysaccharides and other nutrients using the standard. Chemical analysis of the five food thickeners showed variation in ash, protein, fat, moisture and carbohydrate content. Ash content was comparatively high for Nkui and Grewia, with mean contents of 9.01 ±1.5mg and 7.92± 1.1mg respectively. Except for Nkui and Grewia which showed low protein content below 5% whereas, the other three food thickeners had no significant variation in their protein contents.

There were variations in monosaccharide's composition of water soluble and non soluble polysaccharide across the five starch thickeners. Apart from galactose which was comparatively high with a mean value of 18.1±3.1mg in Nduk 1, xylose and fructose were not recorded for any of the water insoluble flour food thickeners.

Keywords: non starch polysaccharide, dietary fibre, diabetes, hyperlipidemia

RESUME

Une étude de source de sous-exploitation de polysaccharide non-amidon dérives de l'aliment de l'Afrique Occidentale était conduit a partir de quatre plantes traditionnel fréquemment utiliser comme épaississeur de l'aliment, notamment, Grewia spp., Triumfetta spp., Beilschmiedia spp. and Irvingia gabonensis, étaient acheter au marche de Maroua, Garoua et Ngaoundéré du Cameroun. L'extraction et isolation de polysaccharide non-soluble à solubilité de l'eau était conduit en utilisant les testes standard pour déterminer la viscosité intrinsèque, la pureté de l'extrait s-NSP et la farine originale aussi que la concentration de polysaccharide et autre nutriments étaient déterminer en utilisant les l'analyse chimique standard de cinq aliment épaississeur a montre la variation de cendre, protéine, la graisse, humidité et taux de glucides. Le taux de cendre était comparativement élever dans Nkui et Grewia avec le taux moyen de 9.01 ±1.5mg and 7.92± 1.1mg respectivement. En dehors de Nkui and Grewia qui ont montre une faible taux de protéine au dessous de 5% alors que les autre trois épaississeur aliment n'avait pas une variation significatif de taux de protéines. Il y'avait variation en composition de monosaccharides solubilité d'eau et polysaccharide non-soluble à travers les cinq épaississeurs d'amidon. En dehors de galactose qui était comparativement élevée avec une valeur moyen de 18.1±3.1mg dans Nduk 1, xylose et fructose n'étaient enregistre pour aucun de farine épaississeur d'aliment de l'eau insoluble.

Mots clés: non amidon polysaccharide, diète fibre, diabètes, hyperlipidémie

INTRODUCTION.

The prevalence of diabetes is on the increase and an estimated 239 million people worldwide are expected to have the condition by the year 2020 (Amos et al., 1997; Ellis et al., 2000). The increase is alarming in the developing world especially in Africa (Egan et al., 1981; Amos et al., 2000; Tairu et al., 2000). This increase is due to the ageing of population and drastic lifestyle changes, accompanied with the urbanisation and westernisation (Fairchild et al., 1996; Isimi et al., 2000). The high urban growth rate comes with dietary changes like increased consumption of high-energy dense foods, refined sugars and saturated fat, and a reduction in fibre rich food intakes (Ghafoor, 1974; Abdulrahman et al., 2004). There is a reduction in physical activity and increase in obesity. This rapid rate of change together with the increasing burden of disease is creating a major public health threat that demands immediate and effective action (Girhammar and Nair, 1992; Amos et al., 1997).

Diabetes can be managed by diet alone, diet and oral hypoglycaemic agents, or diet and insulin (Groop et al., 1993; Tanya et al., 1997; Levitt, 2008). In developing countries like Cameroon, insulin is scarce and very expensive, and most diabetic patients cannot afford to be on insulin or oral hypoglycaemic drugs (Gwatkin et al., 1999; Levitt, 2008). Their only remedy is to be on a diabetic diet, which is not well defined in terms of its composition based on locally available foodstuffs (Egan et al., 1981, Morgan et al., 1990; Lowe et al., 2009). Soluble fibres either as part of a food or as a supplement well mixed with food appear to exhibit the greatest therapeutic effect (Ndjouenkeu et al., 1995; Yilong et al., 2000).

Many of the plant foods utilised in rural areas of Africa are usually very high in carbohydrates (starch and dietary fibre). Some of these have been used to thicken soups or stews, since they have the capacity to solubilise in water and produce high viscosity, and appear to be similar to guar gum, which is rich in a water-soluble galactomannan (Ellis et al., 2000; Ndjouenkeu et al., 1997).

As fibre-rich legume flour, guar gum has received enormous attention from nutritionists as a dietary supplement in the treatment of diabetes and hyperlipidemia and as a model polysaccharide for mechanistic studies (Ghafoor, 1974; Onyechi et al., 1998; Ngondi et al., 2005). A few of these food thickeners, such as Detarium senegalense (Pearson, 1991), Cissus rotundifolia (Agbor, 2005; Oben et al., 2008), Afzelia Africana (Sobgwi et al., 2001), have been studied.

Detarium senegalense was found to be a rich source of dietary fibre the main polymer being a high-molecular-weight xyloglucan (Pearson, 1991; Kuete et al., 2007; Oben et al., 2008). Detarium senegalense and Cissus rotundifolia meals have been found to produce significant reductions in plasma glucose and plasma insulin levels in healthy human subjects (Gautier et al., 2001; Odeku and Patani 2005).

Ndjouenkeu (1995) found that Cissus rotundifolia is a source of xyloglucan. There is lack of information on the rest of these thickeners that are also uncharacterised and under exploited. It is therefore necessary to study more of these food thickeners, which may be good therapeutic sources of plant foods for the management of diabetes mellitus (Morgan et al., 1990; Sobgwi et al., 2001; Ngondi et al., 2005).

Plant foods have remained a useful and cheap source of nutrients for most Africans. Traditionally, they have been used as part of the normal diet in many parts of Africa, especially in rural areas. More recently however, their potential therapeutic and prophylactic benefits have been recognised (Fairchild et al., 1996; Isimi et al., 2000; Fagot-Campagna et al., 2001).

However, guar gum is not commonly known or indeed available in most African countries. Nevertheless, in most rural areas of Cameroon and the rest of Africa, there are numerous plant food preparations used traditionally as thickening agents for soups and stews (Groop et al., 1993; Abdulrahman et al., 2004). In order to establish the fibre contents of some Cameroonian food stuffs mentioned above there is a need to carry out a detailed investigation of the physico-chemical and nutritional properties of some of these food thickeners in order to have a full understanding and allow useful comparisons to be made among different thickeners (Tairu et al., 2000; Agbor et al., 2005).

The aim of the study was to extract and isolate water-soluble non-starch polysaccharides (s-NSP) from four common plant food thickeners used traditionally in Cameroon, to determine the intrinsic viscosity of the extracted s-NSP, and the purity of extracted s-NSP and original flours, by determining the concentration of polysaccharides and other nutrients; and to conduct structural studies of polysaccharide extracts

MATERIALS AND METHODS

Plant food samples

Four commonly used traditional plant food thickeners, namely, Grewia spp., Triumfetta spp., Beilschmiedia spp. and Irvingia gabonensis were bought from the markets of Maroua, Garoua and Ngaoundere in Cameroon. They were packed and sealed in polythene bags and brought to the United Kingdom for laboratory analysis at the Department of Life Sciences, King's College, London.

Grewia spp and Triumfetta spp belong to the same family of Triumfetta. They both grow in some parts of Africa and Pakistan. They are woody shrubs with spreading branches at the base. They produce yellow flowers. The stems are hairy with greenish-white or brownish bark (Ghafoor, 1974; Fairchild et al., 1996). The woody stems are harvested at about 6 months. The bark of the stems is peeled off and locally extracted in warm water. Spices are then added and manually mixed to give a good blend. Besides being eaten with starchy dishes, it is usually consumed as drinks in large quantities by women who have just delivered because it is believed to be a cleansing agent. With the knowledge that viscous fibres improve blood glucose levels by reducing postprandial glucose, insulin, and C-peptide responses in type 2 diabetes (Flammang, et al., 2006), some doctors advise their diabetic patients to take a drink of this viscous solution or soup.

Beilschmiedia and Irvingia belong to the family of Lauraceae. They are both exploited in the form of seeds from trees. For Beilschmiedia spp, there are two types classified on the basis of the seed size. It is a large forest tree and grows mostly in Gabon, Democratic Republic of the Congo, Cameroon and Nigeria (Tanya et al., 1997).

The genus Irvingia Hook is represent in West Africa by three species, namely, Irvingia gabonensis, I. grandifolia and I. smithii. The first two grow in the forest, while the third is found on the riverbanks especially in savana regions. On the basis of fruit characteristics, two varieties of I. gabonensis with different economic values have been identified. The fruit of one variety has sweet edible pulp. Both seeds are used as soup thickeners but that of the bitter type is more preferable because of its viscosity (Tairu et al., 2000; Lowe et al., 2009).

Preparation of Samples

The samples were washed and allowed to dry at room temperature for 24 hours. They were then ground into fine powder using a food blender/mill and passed through a 425μm screen. The flour was immediately put in airtight polythene bags and stored at – 20°C to minimise deterioration of the polymer before further analysis.

Analysis of Plant Foods Samples

The original plant foods were analysed for moisture (104 °C for 16h), fat (Pearson, 1991), crude proteins (Kjeldahl method) and ash method as described by Egan et al.(1981). The polysaccharide isolates, extracted from the flour preparations of the plant foods, were also analysed; including detailed sugar analysis of the polysaccharide(s).

Moisture Determination

The per cent dry weight was determined by drying in an oven empty foil trays, in triplicate and cooled in desiccators. The empty trays were weighed and the weight recorded. The trays were reweighed again with known amounts of each food sample and the food trays were dried in the oven at 105°C for 48 hours, to a constant weight and cooled in a desiccator. The dried food samples and trays were reweighed and the percent weight dry weight (WD) and percentage moisture were determined by their differences (Pearson, 1991).

Fat Analysis

The total fat content was measured by Soxhlet extraction. Soxhlet extraction thimbles and cotton wool were dried in the oven in duplicates and stored in a desiccator. Thimbles and cotton wool were weighed. Known weights of food samples were added into each thimble, reweighed and placed in the extractor. Petrol ether was added. The fat in the food samples was extracted by washing with petrol ether. The fat-free food samples in the thimbles were dried to a constant weight in an oven temperature and cooled in desiccators. The fat-free samples were then reweighed and the fat calculated by difference.

Protein Analysis

The protein analysis was carried out by using the Ref not listed-Kjeldahl method .The food sample was weighed out into a nitrogen-free paper. Duplicate samples were digested in the Kjeldahl apparatus with 20ml of concentrated H_2SO4 and hydrogen peroxide (H_2O_2) was added and the sample heated until the digest was clear, It was cooled and 50 ml of distilled water was added to each sample and the solution transferred to 100 ml volumetric flask and made to volume with distilled water.

Five ml of the samples were distilled in a Markham stem distillation. Boric acid was used to indicate the end point. The protein percentage was calculated using nitrogen conversion factor of 6.25 for the stem plant foods and 5.30 for the seeds or nuts.

Ash Analysis

Dried and cooled crucibles were weighed with the lid. Known amounts of samples were added to the crucibles and reweighed. The crucibles were placed in a muffle furnace at a temperature of 525°C until a clean white ash was obtained and the percentage ash was determined by difference.

Extraction and isolation of s-NSP

About 30 g of each sample was boiled with 150 ml of 70 % (v/v) ethanol for one hour using reflux. Girhammar and Nair (1992), found that the refluxing procedure inactivated endogenous enzymes, dissolved sugars and amino acids and coagulated proteins. The sample was then filtered and washed with 95 % (v/v) ethanol. This was followed by hydration in distilled water (~1500 ml)

at 80°C for 5-10 minutes under stirring and then cooled to room temperature (under stirring). The pH was adjusted to 7.5 using 1M sodium hydroxide. Pancreatin (from porcine pancreatin, Sigma P7545) was added at a concentration of 20ml/100ml extract during the digestion stage. Sodium azide (~0.75%w/v) is added to inhibit microbial activity and the pH was readjusted to 7.5.

The aqueous sample was then incubated at 34°C overnight on a mechanical shaker (Gallenkamp Orbital Incubator). The solution was centrifuged at 6,500g for 25 minutes. The supernatant was removed and precipitated by mixing the sample with absolute alcohol to give a final concentration of 80% (v/v) ethanol. The precipitated polymer was filtered, washed respectively with 95% ethanol, acetone and diethyl ether before freeze-drying for about 24 to 48 hours. After freeze-drying, each sample was ground in a mortar and stored in a desiccator.

Analysis of intrinsic viscosity method

Solutions were prepared by dispersing the known weights of a freeze-dried sample of purified food thickener polysaccharide in deionised water for 1 hour at 80°C and mixed overnight by magnetic stirring at room temperature. The concentrations of s-NSP used for this method were estimated so that the viscosity relative to that of the solvent (water) was within the range of $1.2 < \eta_r < 2.0$, in which the solution viscosity was essentially Newtonian. Both the manual and automatic viscometers were used for the intrinsic viscosity determinations and the values were compared.

Automatic Viscometer: The intrinsic viscosity was determined using the viscosity measuring unit AVS 350 (Schott Gerate, Hofheim, Germany), connected to a Visco-Doser AVS 20 piton burette (for automatic dilutions), to make automated measurements of the flow-through times in a capillary viscometer (Ubbelhode viscometer for dilution sequences). The viscometer was immersed in a precision water bath (transparent thermostat CT 1650, Schott-Geratw, Hofheim, Germany) to maintain the temperature at 25 ± 0.1°C. Results were analysed using separate Huggins and Kramer extrapolations (linear regression, 99% confidence intervals). It was possible to estimate average molecular weight from these values using Mark-Houwink exponentials in the relationship:

$$[\eta] = KM_v^{\alpha}$$

Where Mv is the (viscosity) average molecular weight and the parameters K and α are related to the local stiffness of the polymer (structure chain flexibility) and the long distance structure (excluded volume), respectively.

It was necessary to obtain information about the purity of the polysaccharide and chain flexibility (from light scattering experiments) reliable data on Mv was obtained from intrinsic viscosity data.

Manual Viscometer: This was performed in a dilution capillary viscometer (Cannon Ubbelohde Dilution B glass viscometer, size 50, 8-4.0cst, Glass Artefact (Viscometers), UK) immersed in a water bath to maintain the temperature at 25 ± 0.1°C. Precaution was taken to ensure that the viscometer was aligned vertically, and flow times (>250s) were measured in triplicates while recording the time.

Sugar analysis of original plant food flours and extracted polysaccharides

Sugars alcohols and free sugars of whole flours and the extracted s-NSP were extracted in hot aqueous buffer and measured by gas-liquid chromatography. This provided values for arabinose, xylose, mannose, galactose, glucose, fructose, maltose, sucrose, lactose and their sugar alcohols as applicable. NSP comprised 90% of plant cell-wall material and was a good marker for high fibre diet which is beneficial for health. The analysis involved enzymatic hydrolysis of starch followed by the precipitation of NSP with ethanol. The starch-free residue was constituent sugars, rhamnose, arabinose, xylose, mannose, galactose, glucose, galacturonic acid and glucuronic acid; they were determined by gas-liquid chromatography as mentioned above. Values for soluble and insoluble NSP fractions were also determined.

RESULTS

Chemical Analysis

Chemical analysis of the five food thickeners showed variation in ash, protein, fat, moisture and carbohydrate content (Table 1). Ash content was comparatively high for Nkui and Grewia, with mean contents of 9.01 ±1.5% and 7.92± 1.1% respectively. Except for Nkui and Grewia which showed low protein content lower than 5%, the other three food thickener had no significant variation in their protein contents. The moisture contents of Grewia, Nkui and Khan was not significantly different with mean percentage composition above 8.5% except that Nduk showed low moisture content with mean value of 4.29±0.8 % (Table 1). The variation in carbohydrate content was not significant across the five food thickeners, although big Khan showed the highest carbohydrate content of 82.87±4.5%.

Intrinsic viscosity

There was variation of intrinsic viscosity at different NaCl concentrations. It was shown that viscosity values were high across the NaCl concentration ranges. However, Khan big and small consistently showed low viscosity across the concentration ranges (Table 2).The viscosity of all food thickeners in salt solution was appreciably lower than in water, and the difference increased systematically with decreasing polymer concentration. Their intrinsic viscosities (which is measured from the flow time of a solution through a simple glass capillary and is of considerable historical importance for establishing the very existence of polymer molecules) were 10.6 ±.2 dl/l and 36 ± 2 dl/l respectively (Table 2). Nkui and Nduk or Dika nuts had less than 5% starch present in their extracted NSP. The intrinsic viscosity were 38 ± 2 and 23.4 ± 0.5 dl/l, espectively (Table 2).

Monosaccharide composition of water soluble non soluble starch polysaccharide extracts

The total free sugars in non soluble polysaccharide of the food thickeners were maximum in KHAN-2 and Nduk1, with mean averages of 71.1% (Table 3). Galactose was high in Nduk-2 and Nduk-1 with mean values above 35%. This trend was similar for arabinose with Nduk recording high content (Table 3). However, the rhammose content was high for the Nkui food thickeners, with mean values above 12%. Fructose was not found in any of the thickeners.

Monosaccharide composition of water soluble flour of the food thickeners

The free sugars were generally low in the soluble flour. Apart from galactose which was comparatively high with mean value of 18.1±3.1 g/100g in Nduk 1 (Table 4), the other food thickeners had low free sugars.

The free sugars were very low in the water insoluble flour (Table 5). Xylose and fructose were not found in any of the food thickeners water insoluble flour.

Starch content of purified flour from thickeners

There was a comparative variation in starch content in the purified flour of the thickeners. The starch content of purified sugar was highest for the Khan 1 food thickeners (Fig 1). Nduk 1 and 1 showed very low starch content. For the starch content of the unpurified flour, Khan 1 and 2 were still relatively high in starch content (Fig 2)

DISCUSSION

The results of this study showed that two stem thickeners, Nkui and Grewia which were from the same botanical family (Tiliaces) have the highest ash content, an indication of high mineral content. The protein, fat, moisture and carbohydrate content of these two food thickeners are very similar.

Because of the high intrinsic viscosity readings, the polymer solutions were tested for electro-activity using sodium chloride solutions of different concentrations. There is no available literature on the composition of these thickeners. Except for the great variation in fat, moisture and carbohydrate content, the viscosity and protein values were similar to earlier work reported by Ngondi et al. (2005) and Lowe et al. (2009). However, in their studies they used a 6.25 factor for calculating the Nitrogen value while we used a 5.30 factor as recommended in Pearson's Composition and Analysis of food (Egan et al., 1991; Morgan et al., 1990; Odeku and Patani, 2005). Our values for ash were similar for the two food thickeners (Ndjouenkeu et al.,1997; Oben et al., 2008. Other reports by Tanya et al. (1997) and Fagot-Campagna et al. (2001), quoted values of 54-67% and even 72% for fat content and 38.8% for carbohydrate in Nduk. The four African food thickeners Grewia spp., Triumfetta spp., Beilschmiedia spp. and Irvingia gabonensis showed yield that ranged from about 10% to 25% fat; the highest was that of Nkui. The NSP was screened after the extraction and was found to still have about 5% to 20% starch in two of the samples. The purpose of the extraction was to remove all the starch and proteins. Digesting the polymer with pancreatin which contain amylase, lipase and protease does this (Onyechi et al., 1998; Ellis et al., 2000)

The intrinsic viscosity is one of the most important parameters describing the molecular weight and shape of polysaccharides. It is a property of an isolated polymer molecule, macromolecule, or rigid particle in a given solvent (Ghafoor, 1974; WHO, 2003). This parameter is proportional to the volume occupied by one isolated polymer chain in the solvent. The intrinsic viscosity was measred on the samples that were not completely free from starch. There was a high possibility that this could affect the actual viscosity of the NSP. This was an indication that they might have high molecular weights. There was variation of intrinsic viscosity at different NaCl concentrations. The viscosity values recorded were high across the NaCl concentration ranges. However, Khan big and small consistently showed low viscosity across the concentration ranges. The viscosity of all food thickeners in salt solution were appreciably lower than in water, and the difference increased systematically with decreasing polymer concentration. This type of behaviour is general for

polyelectrolytes (Amos et al., 1997; Tairu et al., 2000; WHO, 2003). In water, the individual coils are expanded by intramolecular electrostatic repulsion. When salt is added, the repulsion is screened and allows the coils to contract to a more compact conformation, with consequent reduction in viscosity (Egan et al., 1981; Ndjouenkeu et al., 1997; Gautier et al., 2001). In order to avoid the complications of changes in coil dimensions on varying polymer concentration, it is advisable that all subsequent studies be performed at fixed ionic strength, by dialysing stock solutions against 0.1 M NaCl and using the dialysate for dilution to lower the concentrations (Tairu et al., 2000; Oben et al., 2008).

Dietary fibre is made up of soluble and insoluble fibres. Most soluble fibres have been shown to have beneficial effects on carbohydrate and lipid metabolism; insoluble fibre on the other hand, is largely responsible for increasing the bulk of faeces, and facilitating taxation. The low frequency of certain metabolic diseases such as diabetes mellitus reported among Africans in the 70s' was attributed to high level of fibre in the African diets (Groop et al., 1993; Gwatkin et al., 1999; Sobgwi et al., 2001). However, reliable data on fibre content and composition of African foodstuffs are not readily available. This study has shown the chemical composition of five thickeners commonly used in the Cameroonian traditional cuisine. Given the physiological importance of fibre fractions, an adequate estimation of dietary fibre should include soluble fibre (Girhammar and Nair, 1992; Ellis et al., 2000).

CONCLUSION

This study has provided useful information on the physico-chemical properties of the non-soluble polysaccharide fibres of five main food thickeners used in the Cameroonian cuisine. High viscosity content of the thickeners is a good indication that it has benefit for the management of type 2 diabetes.

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REFERENCES

1. Abdulrahman F, Inyang IS, Abbah J, Binda L, Amos S, Gamaniel K. Effect of aqueous leaf extract of Irvingia gabonensis on gastrointestinal tract in rodents. Indian J Exp Biol. 42(8):787-91, 2004.
2. Agbor GA, Oben JE, Ngogang JY, Xinxing C, Vinson JA. Antioxidant capacity of some herbs/spices from Cameroon: a comparative study of two methods.J Agric Food Chem; 53(17):6819-6824, 2005.
3. Amos AF, McCarty DJ, Zimmet P. The rising global burden of diabetes and its complications: estimates and projections to the year 2010. Diabet Med 14:81-85, 1997.
4. Egan, H, Kirk R.S, Sawyer R. Pearson's Chemical Analysis of Foods. Churchill Livingstone. Edinburgh. Pp7-34, 1981.
5. Ellis, P.R., Wang Q, Rayment P, Ren Y. and Ross-Murphy, S.B. Guar Gum agricultural and botanical aspects, physicochemical and nutritional properties, and its use in the development of functional foods, In: Choss and Dreher M (eds) Handbook of Dietary Fibre pp. 613-657, 2000.
6. Fagot-Campagna A, Pettitt DJ, Engelgau MM. Type 2 Diabetes among North American children and adolescents: an epidemiological review and a public health perspective. J. Pediatr; 6:664-672, 2001.
7. Fairchild RM, Ellis PR, Byrne AJ, Luizio SD, Mir MA. A new breakfast cereal containing guar gum reduces postprandial plasma glucose and insulin concentrations in normal-weight human subjects. Br J Nutr. 76:63-73, 1996.
8. Flammang AM, Kendall DM, Baumgartnerm CJ, Trish D. Slagle TD, and Yong S. Choe YS. Effect of a Viscous Fiber Bar on Postprandial Glycemia in Subjects with Type 2 Diabetes. Journal of the American College of Nutrition, Vol. 25, No. 5, 409-414, 2006.
9. Gautier JF, Sobngwi E, Vexiau P. Comment je traite et prends en charge un diabete du sujet Noir. Journ Annu Diabetol Hotel Dieu. 165-178, 2001.
10. Ghafoor A. Flora of Pakistan (ed) Nasir, E., Steward Herbarium Gordon College Rawalpindi and Ali, SI., Dept. of Botany Univ. Karachi No. 75, 1974.
11. Girhammar U, Nair B.M. Isolation, separation and characterization of water soluble non-starch polysaccharides from wheat and rye. FD. Hydrocoll. 6:285-299, 1992.
12. Groop P.H, Aro A, Stenman S, Groop L. Long term effects of guar gum In subjects with non- insulin-dependent diabetes mellitus. Am J Clin; 58:513 518, 1993.
13. Gwatkin D, Guillot M, Heuveline P. The burden of disease among the global poor. Lancet. 354: 586-589, 1999.
14. Isimi CY, Kunle OO, Bangudu AB. Some emulsifying and suspending properties of the mucilage extracted from kernels of Irvingia gabonensis. Boll Chim Farm.; 139(5):199-204, 2000.
15. Kuete V, Wabo GF, Ngameni B, Mbaveng AT, Metuno R, Etoa FX, Ngadjui BT, Beng VP, Meyer JJ, Lall N. Antimicrobial activity of the methanolic extract, fractions and compounds from the stem bark of Irvingia gabonensis (Ixonanthaceae). J Ethnopharmacol; 114(1):54-60, 2007.

16. Levitt NS. Diabetes in Africa: epidemiology, management and healthcare challenges. Heart.; 94:1376-1382, 2008.
17. Lowe AJ, Gillies AC, Wilson J, Dawson IK. Conservation genetics of bush mango from central/west Africa: implications from random amplified polymorphic DNA analysis. Mol Ecol; 7:831-41, 2009.
18. Morgan LM, Tredger JA, Wright J, Marks V. The effect of soluble and insoluble-fibre supplementation on post-prandial glucose tolerance, insulin and gastric inhibitory polypeptide secretion in healthy subjects. Br J Nutr; 64:101-103, 1990.
19. Ndjouenkeu R, Goycoolea FM, Morris ER, and Akingbala JO. Rheology of okro (Hibiscus esculentus L.) and dika nut (Irivingia gabonensis) Polysaccharides. Carb Polym.; 29**:**263-269, 1995.
20. Ndjouenkeu R, Akingbala JO, Oguntimein GB.Emulsifying properties of three African food hydrocolloids: okro (Hibiscus esulentus), dikanut (Irvingia gabonensis), and Khan (Belshmiedia sp.). Plant Foods for Human Nutrition. 51: 245-255, 1997.
21. Ngondi JL, Oben JE, Minka SR. The effect of Irvingia gabonensis seeds on body weight and blood lipids of obese subjects in Cameroon. Lipids Health Dis. 25:4-12, 2005.
22. Oben JE, Ngondi JL, Momo CN, Agbor GA, Sobgwui CS. The use of a Cissus quadrangularis/Irvingia gabonensis combination in the management of weight loss: a double-blind placebo-controlled study.Lipids Health Dis.; 31:7 12, 2008.
23. Odeku OA, Patani BO. Evaluation of dika nut mucilage (Irvingia gabonensis) as binding agent in metronidazole tablet formulations. Pharm Dev Technol.; 10(3):439-46, 2005.
24. Onyechi, U.A, Judd P.A, Ellis PR. African plant foods rich in non- starch polysaccharides reduce postprandial blood glucose and insulin concentrations in healthy human subjects. Brit. J. Nutr; 80: 419-428, 1998.
25. Pearson D. The chemical analysis of foods 7TH Ed. Church Livingstone Longman group Limited: pp 493-494.), 1991.
26. Sobgwi E, Mauvais F, Vexiau P, Mbanya JC, Gautier JF. Diabetes in Africans. Part 1: epidemiology and Clinical specificaties. Diabetes Meta (Paris). 27:628-634, 2001.
27. Tairu AO, Hofmann T, Schieberle P. Studies on the key odorants formed by roasting of wild mango seeds (Irvingia gabonensis).J Agric Food Chem 48(6):2391-4, 2000
28. Tanya AN, Mbofung CM, Keshinro OO. Soluble and insoluble fibre contents of some camerooninan foodstuffs. Plant Food Hum. Nutr; 51:199-207, 1997.
29. Yilong Ren, David R. Picout, Peter R. Ellis Simon B. Ross-Murphy and JS, Grant R. A novel xyloglucan from seeds of Afzelia africana Se. Pers.—extraction, characterization, and conformational properties. Carbo. Res. 340; 5:997-1005, 2000.
30. World Health Organization (WHO/FAO). Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases WHO Joint – Geneva, Switzerland: WHO Press.pp211, 2003.

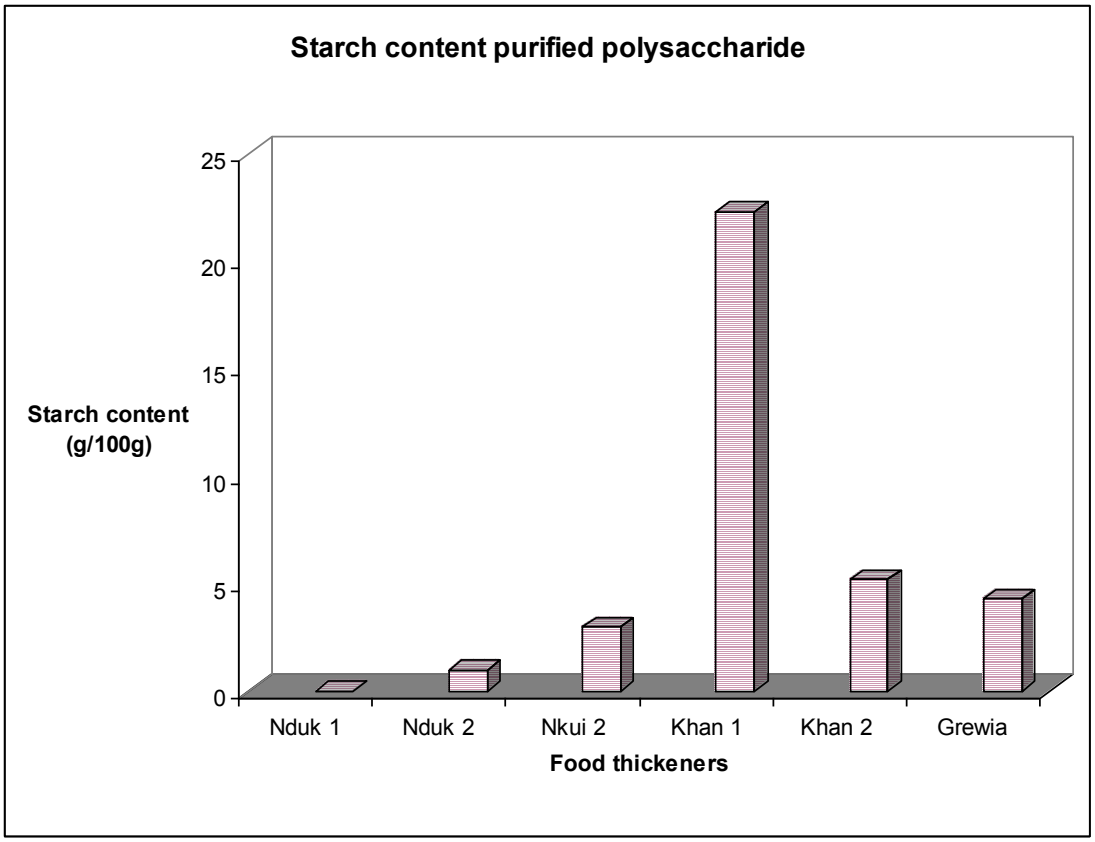

Figure :1:Starch content of purified flour from food thickeners

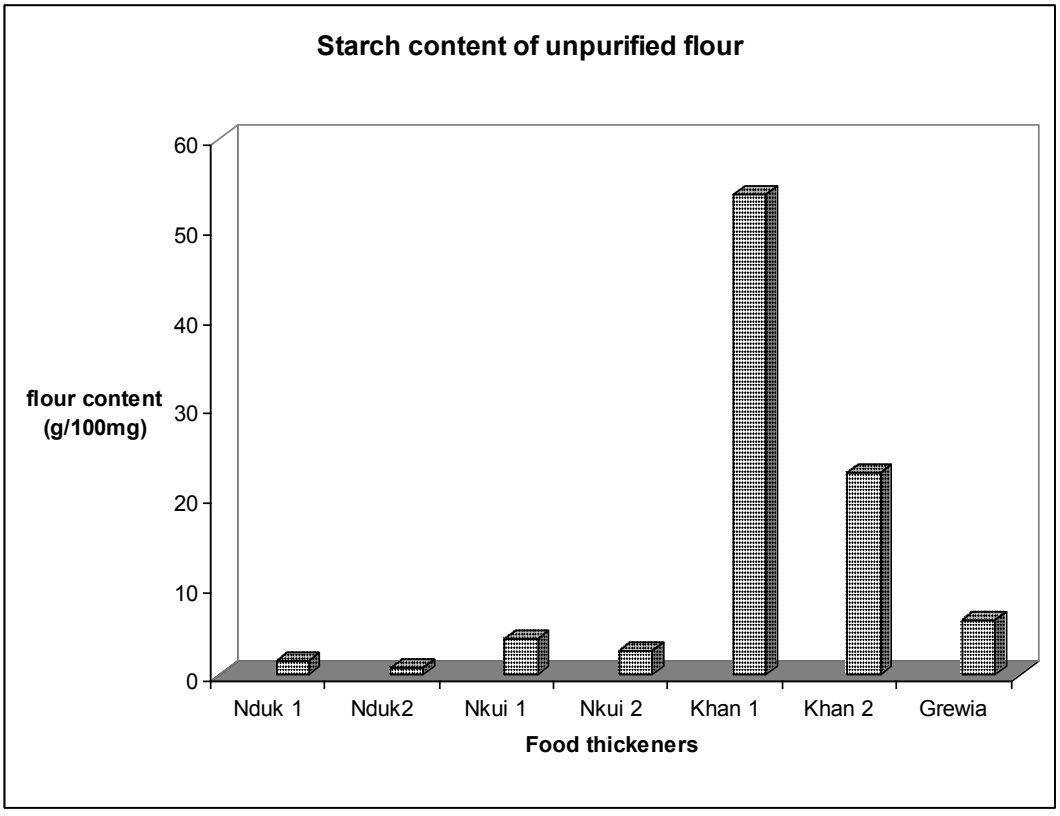

Figure 2: Starch content of unpurified flour from food thickeners

Table 1 Mean percentages of chemical composition of Nduk, Grewia, Nkui and Khan

Food Sample	Composition (%), Mean ± Standard deviation				
	Ash	**Protein**	**Fat**	**Moisture**	**Carbohydrate**
Nduk	1.703±0.0	7.22±1.1	8.2±6.6	4.29±0.8	67.67±5.5
Grewia	7.92±1.1	4.73±0.0	3.12±0.1	8.62±2.0	75.61±3.9
Nkui	9.01±1.5	3.98±0.7	5.27±0.9	10.21±1.7	71.53±6.6
Khan Sm.	1.52±0.0	6.18±1.5	6.39±0.5	10.46±2.6	75.45±8.2
Khan Big	2.23±0.0	6.17±0.9	4.41±0.7	10.05±1.2	82.87±4.6

Table 2 Intrinsic Viscosities of s-NSP from African Food Thickeners (dl/l)

Food thickeners	0 M NaCl	0.01 M NaCl	0.1 M NaCl	0.2 M NaCl
Grewia	$\eta = 36 \pm 2$	$\eta = 15.85 \pm 0.02$	$\eta = 11.4 \pm 0.3$	$\eta = 9.9 \pm 0.2$
Nkui	$\eta = 38 \pm 2$	$\eta = 23.2 \pm 0.2$	$\eta = 18.6 \pm 0.8$	$\eta = 17.9 \pm 0.8$
Nkan (big)	$\eta = 13.3 \pm 0.4$	$\eta = 11.9 \pm 0.4$	$\eta = 9.8 \pm 0.4$	$\eta = 11.0 \pm 0.5$
Nkan (small)	$\eta = 10.6 \pm 0.2$	$\eta = 10.5 \pm 0.2$	$\eta = 7.4 \pm 0.3$	$\eta = 11.1 \pm 0.1$
Nduk	$\eta = 23.4 \pm 0.5$	$\eta = 12.35 \pm 0.4$	$\eta = 7.9 \pm 0.1$	$\eta = 7.25 \pm 0.1$

Table 3: Monosaccharide Composition of the water soluble NSP extract from the African Food thickeners

Free Sugars	Monosacharide Composition Mean ± Standard deviation (%)						
	NDUK-1	**NKUI-1**	**KHAN-1**	**GREWIA**	**NDUK-2**	**NKUI-2**	KHAN-2
Rhamnose	4.0 ±0.3	12.2±2.3	0.0±0.0	0.0±0.0	2.2±0.5	13.1±0.1	**0.0±0.0**
Arabinose	15.9± 2.3	1.6±0.5	30.4±1.4	32.4±2.0	20.1±3.6	1.4±0.1	**31.5±0.9**
Mannose	3.0 ± 0.7	4.3±0.8	1.8±0.9	2.2±0.9	1.5±1.2	3.8±0.5	**2.2±0.5**
Galactose	35.8 ± 3.9	6.8±0.6	0.0±0.0	0.0±0.0	38.0±1.8	6.6±0.6	**0.0±0.0**
Galacturonic acid	5.0 ± 0.4	11.1±1.5	1.1±0.3	1.3±0.5	4.6±0.3	11.1±0.3	**1.5±0.5**
Glucose	0.0±0.0	5.9±0.7	0.0±0.0	0.0±0.0	0.0±0.0	3.1±0.3	**0.0±0.0**
Xylose	0.0±0.0	4.6±0.1	16.7±1.4	17.2±1.0	0.0±0.0	5.1±0.2	**16.3±1.2**
Fructose	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0-	**0.0±0.0-**
Total	**63.8 ±7.6**	**46.5±5.2**	**50.1±4.0**	**52.5±7.6**	**61.8±7.4**	**44.2±2.1**	**71.1±4.1**

Table 4: **Monosaccharide Composition of the water soluble flour of the African Food thickeners**

Free Sugars	Monosacharide Composition of Soluble flour (g/100g dry matter) Mean ± Standard Deviation			
	NDUK-1	**NKUI-1**	**KHAN-1**	GREWIA
Rhamnose	0.0±0.0	0.0±0.0	0.0±0.0	**0.0±0.0**
Arabinose	7.8±0.4	2.3±0.5	5.8±0.9	**6.2±0.7**
Mannose	0.6±0.0	0.2±0.0	0.2±0.0	**3.1±0.3**
Galactose	18.1±3.1	0.0±0.0	1.1±0.3	**1.4±0.0**
Galacturonic acid	1.7±0.3	2.2±0.1	0.9±0.3	**1.6±0.2**
Glucose	0.0±0.0	0.0±0.0	1.0±0.2	**1.2±0.0**
Xylose	0.0±0.0	0.0±0.0	2.2±0.0	**0.0±0.0**
Fructose	0.0±0.0	0.0±0.0	0.0±0.0	**2.2±0.0**
Total	**28.1±3.2**	**4.5±0.6**	**10.3±2.9**	**12.5±1.7**

Table 5: Monosaccharide Composition of the water insoluble flour from the African Food thickeners

Free Sugars	Monosaccharide Composition (g /100g dry matter) Mean ± Standard Deviation			
	NDUK	**NKUI**	**KHAN**	GREWIA
Rhamnose	1.6±0.1	0.0±0.0	0.0±0.0	**0.0±0.0**
Arabinose	2.5±0.7	0.0±0.0	0.6±0.0	**0.7±0.2**
Mannose	0.0±0.0	1.3±0.3	0.0±0.0	**0.0±0.0**
Galactose	0.0±0.0	0.2±0.0	0.4±0.0	**0.4±0.0**
Galacturonic acid	1.1±0.1	2.7±0.3	1.0±0.0	**1.3±0.4**
Glucose	0.0±0.0	1.7±0.3	0.2±0.0	**0.4±0.0**
Xylose	0.0±0.0	0.0±0.0	0.0±0.0	**0.0±0.0**
Fructose	0.0±0.0-	0.0±0.0	0.0±0.0	**0.0±0.0**
Total	**5.2±0.9**	**5.9±0.9**	**1.2±0.2**	**2. 7±0.6**